# AFFIDAVIT OF STEWART HOUGH

**RE: U.S. Patent Application No.: 10/551,204 filed September 23, 2005 for LED ILLUMINATION SOURCE/DISPLAY WITH INDIVIDUAL LED BRIGHTNESS MONITORING CAPABILITY AND CALIBRATION AND METHOD and corresponding applications pending in other countries including EPC Application No. 0476285.9**

I, Stewart Hough, being duly sworn state:

I am a physicist with considerable experience in the development and commercialization of emerging technologies in electronics, electronic displays, solid-state lighting and make this affidavit in support of the above patent applications.

At the request of Mr. Harold L. Jackson, U.S. counsel for the assignee of the above application, Visioneered Image Systems, Inc., I have reviewed the following patents/applications cited by the European Patent Office ("EPO"), in a search report on the subject application EP Application No. 0476285.9 ("Visioneered's application"), as being particularly relevant to the patentability of the disclosed display and method when considered alone, Nos. 1 and 2, and being relevant as providing technological background (Nos. 3-5):

1. Patent application US2002/047550, inventor Tanada Yoshifumi ("Yoshifumi")
2. European patent EP1194013, applicant Eastman Kodak Company ("Kodak I")
3. European patent EP1077444, applicant Agilent Technologies ("Agilent")
4. Patent US 6291942B1, inventor Odagiri Hiroshi et al, assignee Seiko Instruments ("Odagiri/Seiko")
5. European patent EP1335430, applicant Eastman Kodak Company ("Kodak II")

I have also reviewed Visioneered's application.

## PURPOSE

This report is a review and analysis of the cited patents/application ("cited prior art" or "references") by the EPO to determine their relevance to the video display apparatus described and claimed in Visioneered's application. General issues surrounding the potential relevance of the prior art as a whole are discussed as well as references 1 and 2 individually.

## QUALIFICATIONS

My qualifications for providing this analysis and my opinion as to the nonobviousness of the invention described and claimed in Visioneered's application are set forth in my CV which is attached as Ex. A.

## DISPLAY TECHNOLOGY OVERVIEW

Electronic displays are highly complex electronic devices that require a wide range of engineering disciplines to create a viable commercial product. A broad array of technologies and design approaches must be utilized to produce an image generating display device, as evidenced by the large number of display types presently available in the commercial marketplace and the enormous financial investments that continue to be made. Of all electronic devices, electronic displays incorporate the widest and most disparate range of materials, components, semiconductors, electronics, optics, process technology and systems design. Fundamental as well as highly specific understanding in detailed areas of science and engineering is necessary to develop a commercially viable product.

While there are similarities in the basic function of electronic displays, each display type relies on highly specific and unique technology and design development and in most cases discovery, innovation, knowledge and learning. Electronic image generating displays convert

electrical energy into light energy or provide some physical or chemical change of materials, elements or components with the primary purpose of producing sufficient image contrast between independently addressable picture elements (pixels) of the display that are activated, partially activated, or not activated to allow information or some visual effect to be generated. The specific means by which this is accomplished is the basis for the complexity and diversity of electronic display types.

The general types of electronic displays may be categorized as: Emissive, using self-generating lighting elements, defined as emissive displays, e.g., Plasma Display Panel (PDP), Field Emission Display (FED), cathode ray tube (CRT), vacuum fluorescent (VF), electroluminescence (EL), organic light emitting diode (OLED), light emitting diode (LED), etc.; Reflective, using light membranes, inks, polymers, mechanical structures, or valves that reflect ambient light or modulate light input sources, e.g., Liquid Crystal Display (LCD), Liquid Crystal On Silicon (LCOS), Microelectronic Mechanical Systems (MEMs), Digital Mirror Device (DMD), electrophoretic, electrochromic, etc.), or; a hybrid combination of the above to produce the necessary image contrast differentiation. The precise structures and methods used to accomplish this are unique to each technology and, in my opinion, would not be obvious to the ordinary skilled artisan except at the fundamental operational theory and elemental design level. Detailed material, component, and system engineering knowledge based on experience, analysis, design, calculation, development, fabrication, prototype assembly and testing are required to understand the specific requirements of each technology in order to create a viable display and accomplish the needed contrast control.

## VISIONEERED'S VIDEO DISPLAY APPARATUS

The Visioneered application is directed to an illumination source/display and more particularly to an Outdoor LED Video/Image Display in the form of an electronic billboard utilizing a plurality of discrete inorganic light emitting diodes (LEDs) illustrated in Figs. 3-6a of the application. The LEDs are packaged individually or together to form each pixel (or group) in the arrays or modules forming the billboard. The discrete LEDs are also described as LED-DIEs with the DIE notation referring to the dicing process used during the manufacture to separate the individual or chip set LEDs. Photodiodes are associated with each LED or pixel for providing illumination intensity signals.

The terminology of claim 1, i.e., an LED video display apparatus having a plurality of individual groups (or pixels) of single or multi-chip LEDs with each individual group consisting of (or comprising) a plurality of LEDs packaged singly or together distinguishes Visioneered's display from the displays taught in the cited references, for example, the OLED monolithic flat panel displays of refs. 1, 2, 4 and 5. The addition of least one light sensor capable of providing a separate feedback signal representative of the luminance output from each LED distinguishes Visioneered's system from conventional electronic billboards. An optical element, such as a lens/reflector, serves to project the light from the LEDs to the observer while the same element and/or internal reflectors serve to feed back a portion of the light to the photodiodes for self-calibration and other purposes as described in Visioneered's application. The displays described in the cited references are neither designed for nor would they be practical for displaying information in an outdoor daylight setting. Based on my review of the cited prior art and my experience it is my firm opinion that Visioneered's inventors have made a nonobvious step

forward in the discrete LED video display art as will be explained.

## RELEVANCE ISSUES OF THE CITED PRIOR ART

### 1. Categorization of the Prior Art Displays

Table 1 below lists the cited references and their specified display technology application.

| Inventor/Applicant | App./patent no. | Filing date | Application/Display Type |
|---|---|---|---|
| Yoshifumi | 20020047550 | 25.04.2002 | Monolithic array OLED, PDP, FED, |
| Kodak I | EP1194013 | 19.09.2001 | Monolithic array OLED |
| Agilent | EP1077444 | 28.06.2000 | Integrated circuit (Microdisplay)display |
| Odagiri/Seiko | US6291942 | 18.09.2001 | Monolithic segmented EL and OEL |
| Kodak II | EP1335430 | 31.01.2003 | Monolithic array OLED |

### 2. Monolithic Structures Versus Discrete Assemblies

Each of the prior art references explicitly identifies display technologies that utilize self-light emitting elements or light sources for emissive segmented or pixelated displays, or for reflected operation on an integrated circuit or monolithic passive or active matrix substrate of metal, glass or plastic. The specific design techniques used for providing self-lighting elements, optical feedback elements (where present) and compensation methods are unique to the structure of each integrated device as well as each technology, despite the general similarity of intended approach.

Specifically, the Agilent patent utilizes light sources to illuminate reflective integrated circuit based displays, generally referred to as microdisplay technology. The Odagiri/Seiko and Kodak I and II instruments are directed to EL and OEL(OLED) displays. OLED is called OEL in

Asia and is part of a general class of displays referred to as EL, for electroluminescence. The Yoshifumi application is directed to EL and OEL(OLED) as well as FED and PDP; all monolithic emissive type displays. As further indication of intent, the application figures for the Yoshifumi reference are only consumer product display types, e.g., camcorder, notebook, cellphone, automotive, headset, DVD player or desktop monitor.

The figures in the cited references show specific multi-layer structures that are unique to monolithic thin film solid-state devices, including conduction, electron and hole transport and electroluminescent layers in the case of OLEDs, and silicon masked integrated circuits for microdisplays. Other figures (Yoshifumi) show active matrix backplane schemes with deposited materials that are configured to enable light emission as well as photo-sensitive operation. Consequently, brightness correction implementation is directed to the embedding of the means to accomplish optical feedback and adjustment within a monolithic structure.

In contrast, Visioneered's application is directed to a non-monolithic emissive display structure using a plurality of discrete components configured as an assembled unit and that utilize inorganic light emitting diodes (LEDs), which is clearly and significantly differentiated from the monolithic approach used in the cited prior art.

**3. No Reference to Discrete LEDs used as Video/Image generating Devices in the Cited Prior Art**

In my opinion none of the prior art teachings are applicable to displays using inorganic LEDs as light emitting elements. This is understandable due to the disparate nature of discrete LED technology versus integrated circuit and monolithic substrate display technologies mentioned in 2. above. The prior art teaches the application of optical feedback mechanisms

only in a limited manner for monolithic and integrated substrate displays and offers no optical feedback mechanisms for discrete LED display devices.

The Kodak II reference refers to LEDs in the context of their electrical function as semiconductors, not to LEDs as light generating elements. OLEDs are electrically the organic analog of inorganic LEDs, which allow electrical current to flow in one direction and resist current flow in the opposite direction. This fundamental similarity in electrical property between LEDs and OLEDs makes it logical in a discussion of the electrical theory and operation of the OLEDs cited to include reference to inorganic LEDs as electrical elements, however, LEDs as self-light emitting elements is not addressed.

The Agilent reference applies to LEDs or other light sources used to illuminate reflective microdisplays where the photo-sensitive elements are part of the integrated circuit display and the LEDs are not used as discrete self-lighting elements for direct image generating devices nor are they differentiated from other potential light sources that could accomplish the same function.

Visioneered's application is uniquely focused on the application of inorganic LED technology to directly viewed electronic image generating display devices, not as illuminating light sources for other controlled elements which in turn provide the displayed image.

**4. References to the use of Optical Feedback in the Cited Prior Art are not Applicable to Visioneered's Display**

The use of photo-sensitive devices to detect the presence or absence of light energy and to feedback this result to some controlling circuit and thereby modulate the source of the light energy is a common practice and understood by those experienced in the art. This fact is

expressly alluded to in several of the cited references, specifically the Odagiri/Seiko patent by general reference to the practice and the Kodak II patent by reference to specific prior art upon which the Kodak patent claims improved performance and advantages. The teachings in the cited references relating to optical feedback mechanisms is not a broad teaching that transcends multiple display technologies, rather it is a specific teaching that relates to the identified display technology. The invention disclosed and claimed in Visioneered's application resides in the knowledge of the need to perform this optical feedback in an LED billboard display and in the specific requirements and structure to accomplish the optical feedback.

For example, CRT display technology does not facilitate the use of optical feedback elements and control intrinsically or from systems employing self-lighting elements to improve intrinsic uniformity, or reduce aging, etc. The structure of PDP display technology also does not readily facilitate optical feedback mechanisms intrinsically nor from those developed in other display systems, even though Yoshifumi incorporates the application to PDP in his patents and application.

OLED and LCOS microdisplay technologies readily facilitate the incorporation of optical feedback due to their thin film, monolithic design, as identified in the Agilent, Odagiri/Seiko, Yoshifumi and Kodak patents. The uniqueness of the means to accomplish this is only applicable to each technology type.

Visioneered's application applies specific optical feedback mechanisms in discrete component LED matrix displays, which are uniquely differentiated in the required understanding of LED component characteristics, chip technologies, sensitivities, production tolerances and variations, aging, environmental and usage effects. These factors are unique to discrete LED

type display devices and not directly related or similar in detail to monolithic thin film or integrated circuit display devices.

### 5. Unique Calibration Requirements

The requirements for calibration and the methods used to calibrate light emitting segments or pixels of an electronic display device are unique to each specific display technology, even though the general principle and purpose of calibration is similar. In particular, self light emitting display technologies, e.g., FED, PDP, OLED, EL, etc., are uniquely structured and electronically addressed and activated, requiring special developed techniques to perform the calibration of pixels. Even non-self light emitting displays, such as LCDs, and DMD and LCOS microdisplays, can require calibration, and are also unique to the specific technology type. In my opinion, accomplishing effective calibration design requires a detailed and unique understanding of each technology type as well as the development of specific methodologies for each display type. The above mentioned display technologies are constructed as monolithic structures in a flat panel configuration, which demands unique knowledge of drive methods, power sources and structure for these device types.

Visioneered's application is further unique in that it requires an understanding and analysis of the specific characteristics of packaged LED devices that are based on disparate semiconductor technologies, e.g., InGaN / SiC & InGaN /AlO2 blue/ultraviolet or Green LEDs and AlInGaP Red, which possess unique non-uniformity and degradation characteristics that are different from the characteristics of the monolithic flat panel display technologies cited above.

### 6. Mechanisms for Optical Feedback

The cited references refer to the use of optical feedback from self-lighting elements to be accomplished using various means, including direct, indirect, filtered, and optically guided methods through reflection and transmission through the intrinsic structures.

In particular, Yoshifumi does not specify any lens, material layer, structure, reflector or the specifics of any designed optical path invention for feedback. Both Kodak patents provide for direct absorption by photo-sensitive material, also reflected from substrate or cover and passed back through the structure, however, no specifics related to structure, processes, design or materials are provided.

The Agilent patent is focused on illumination of integrated circuit displays with external or internal light sources. Because the position of the light sources is above and illuminating directly onto the integrated circuit, the photo-sensitive elements are directly illuminated along with the reflective display elements, obviating any reflectors or optical paths, but implying the use of optical filters and transmission barriers to limit the amount of incident illumination. However, no description of reflection or optical control devices or components is provided. More importantly, the calibration and compensation of the illumination sources does not adjust for pixel level variations, as the Kodak and Yoshifumi references allow for, rather only the adjustment of the illumination source, such as an LED.

The Odagiri/Seiko patent does not address the optical feedback paths between the self-light emitting elements and the photo-sensitive elements.

Even though one of the characteristics of monolithic display structures is optical wave guiding, internal reflection and light scattering within the layer structure, none of the cited

documents provides sufficient design and detail to isolate, eliminate or reduce internal scattering from adjacent lighted elements that could affect the self-light emitting element calibration and adjustment and ensure optical feedback integrity of individual optical pixel level feedback signals.

In contrast, Visioneered's application details specific design inventions for isolated pixel, reflected optical paths for pixel level arrays of discrete LEDs to compensate for the general display and pixel level degradation of light output and to uniquely provide isolation to the pixel level of the individual optical feedback signals.

### 7. Detailed, Unique Compensation Methods

Several of the cited references refer to specific procedures and methods for adjusting the self-lighting elements to restore uniformity due to changes in light output. Each of these procedures follows a specific sequence of logical instructions to accomplish these using diverse methods, e.g., electrical hardware, software/firmware, algorithms, programmed controllers. The methodological design required for integrated circuits or monolithic displays are unique to each type of display.

In contrast, Visioneered's application prescribes a detailed method, flow chart and algorithms for calibrating and adjusting LED device light output that is unique to Visioneered's invention and uniquely applicable to discrete LED arrays used as image generating devices.

## 8. Scale and Dimensions of Device Structures Impacts Optical Feedback Specifications

The materials, design, construction and fabrication methods used in diverse display technologies result from novel invention, research and development through utilization of a wide array of engineering disciplines to optimize the display image contrast performance as well as the cost to manufacture any resulting display product. In general, the unique physical construction and design scale of display technologies have followed a progression of development similar to that experienced in semiconductor technology.

Initial semiconductor devices were on the scale of tens and hundreds of microns in critical feature size and overall geometry with tolerances, clearances and resolution of fabrication equipment an order of a magnitude smaller. Present state of the art in semiconductors use critical design resolutions on the order of 50 nanometers, representing up to 5 orders of magnitude change over time. This scaling factor has been possible with improvements in imaging resolution, deposition accuracy and rates, etching precision, lithography detail, positioning accuracy, and mask design and alignment as well as other fabrication and manufacturing technologies. This trend in semiconductor device technology is expected to continue until physical limits related to the intrinsic semiconductor physics at the atomic and quantum level are reached. Display technologies have directly benefitted from and readily adopted these advances.

Cathode ray tubes, the first mass-produced display technology, have display features on the order of millimeters in size. PDP, EL, and passive LCD technology use micron scale resolutions and features. High resolution LCDs with active matrix substrates use sub-micron geometries and tolerances. LCOS, OLED and Quantum dot display technologies have pushed the

state of the art in requirements for design and manufacturing technologies to the nanometer (nm) and even sub-nanometer scale. Film layer geometries only a few molecules in thickness are now being routinely deposited. Because the wavelength of visible light ranges from approx. 450 nm to 780 nm, display technologies that have feature sizes and film thicknesses on this order and smaller require entirely novel and diverse technology solutions to optimize their performance due to their impact on the fundamental properties of visible light.

Whether in the two dimensional plane of the display device substrate or the third dimensional axis of the layer deposition and primary light extraction, features and device geometries on the order of magnitude of the wavelength of light introduce significant diffraction, refraction, reflection, wave guiding, light piping, absorption, transmission, color shift and filtering effects. For example, OLED displays presently only emit approx. 30% of the total light generated. Much of the OLED technology development focus is on inventions for extracting a higher percentage of the internally generated light, a parameter measured as external quantum efficiency. To direct the light to where it is needed, incorporation of specific layers, structures and features and the selection of specialized light management materials are major approaches under pursuit. The above effects apply directly to the specifications and descriptions used in the cited documents to accomplish optical feedback by directing emitted light to photosensitive elements.

Specifically, the Kodak II patent details the layer definition and basic structure of OLED thin film monolithic devices with particular specifications in Figures 2 through 6 related to layer construction and stacking and light paths for optical feedback from light emitting areas to photosensitive elements. Whether the optical feedback method and design in the display devices

described in the cited documents are specified as intrinsic to the monolithic structure, or specified as through alternative means, the specific design and invention needed to accomplish the optical feedback is unique to each technology and significantly different in invention, design and construction from the discrete display device approach specified by the Visioneered application.

Firstly, the thermal, electrical, chemical, morphological and rheological properties of the materials used in thin film monolithic display devices such as LCD, OLED and PDP and alluded to but not specifically described in the Kodak II patent are critical and unique to OLED display technology. Secondly, the design and construction of the layers, structures and features of the device used to manage light extraction and optical feedback are also distinct due to the dimensional scale of the internal layers, as indicated by the Kodak II invention. Thirdly, the materials, layers and structures must be compatible with the deposition methods used, as also mentioned in the Kodak II patent. Application of the Kodak inventions to LCD, LCOS, or PDP display technology is possible, but, due to geometric scales, unique layer stacking and structure, construction techniques and operational methods, only in a limited manner. None of these specifications apply to discrete display devices as embodied by the Visioneered application.

Display technologies make use of common technologies where possible, but the high cost and risk associated with display technology development is directly related to the value and effectiveness of the inventions needed in the uncommon areas. The inorganic LED semiconductor technology of the type used in the discrete packaged devices in Visioneered's application uses structures with features on the sub-micron order at the LED die level, which are significantly impacted by the optical effects mentioned above. Further, the discrete optical

packages into which the LED die is assembled are highly engineered for maximum external quantum efficiency. The package types are on the order of millimeters in size, consequently the inventions incorporated to provide optical feedback and light management in discrete arrays of these devices are unique to this packaging technology and to assembled arrays of discrete packaged LED devices.

The in situ positioning of optical feedback elements within the monolithic structures of the display devices referenced in the cited documents requires specific technologies and developments to consider the above light management related issues. In contrast, the optical feedback design accomplished through the selection of materials and the specific design and construction to manage light extraction, reflection and light paths of the discrete display device approach used in the Visioneered application are also unique.

**9. Individual Reference Review**

This section identifies some specific attributes and differences between references nos. 1 and 2 and Visioneered's application.

**a. The Yoshifumi Reference**

1. Focuses on integrated/monolithic substrates, not discrete component arrays.
2. No mention of electronic billboard applications.
3. No mention of discrete LEDs or LED displays.
4. No mention of compensating for LED device variation.
5. Does not mention the object of overcoming initial light emitting element non-uniformity.

6. Prescribes an optical, electrical and software mechanism for sampling and correcting light output, but does not prescribe a mechanical device or configuration for a pixel that would facilitate the correction of light output. Does not specify any lens or reflector or other optical path for correction feedback.
7. Uses time-based modulation of activation energy to correct brightness variations consistent with PDP displays but does not reference other display types.
8. Specifies an integrated silicon control circuit but does not reference other display types: it is limited to the monolithic structures specified.
9. Photoconversion elements are insitu, not discrete assembled components.
10. Does not include ambient light rejection.
11. Does not consider pixel failure detection.
12. Does not consider ambient light adjustment or partial display obstruction/shadowing.
13. Does not specify on and off measurements to subtract ambient light levels.
14. Does not specify testing for color balance white point calibration.

15. Specifies a start-up test pattern for establishing uniformity drive values by storing a test pattern in memory for testing the array, but does not specify any factory calibration or characterization method.

**b. The Kodak I Reference - A flat panel display with luminance feedback**

1. Precedes Kodak II patent - An image display, includes a substrate, a light emitter formed on the substrate, and a photo-sensor formed on the substrated and optically coupled directly to the light emitter, not a discrete component array.
2. Relates to solid-state monolithic OLED displays, not discrete arrays of light emitting elements.
3. Photoelectric response based on photo-sensitive materials, amorphous silicon, poly-silicon, organic materials, or silicon photodiodes, all integrated on the light-emitting element substrate, not implemented as discrete components.
4. Compensation for aging, temperature humidity or other environmental stress.
5. Direct absorption by photo-sensitive material, also reflected from substrate or cover and pass back through, no design details specified.

6. Internal reflection between light emitters and detectors by total internal reflection, faceplate and emission layer, electrodes, and any other optical coupling mechanism, no design details specified.
7. Ambient light current feedback.
8. Calibration of pixels by changing the current based on comparison of photo-sensor feedback and a priori knowledge.
9. Single, grouped or individual color feedback signals.
10. Internally integrated feedback circuitry or separate circuitry for passive or active matrix displays.
11. Photo-sensors are optically transparent and single grouped or individual photo-sensors formed on the substrate.

**SUMMARY**

Visioneered's application addresses the requirements for optical feedback compensation for discrete LED array image generating display devices. Unique design solutions are described for optical performance issues for discrete LED array based displays over the predictive methods as well as the impractical external monitoring, measurement and recording methods prescribed in prior art. The cited references provide overall techniques and specific requirements for monolithic display-based technologies to compensate for self-light emitting element variation or the illumination of integrated circuit displays that adopt the general methods, but not the specific and unique requirements of discrete LED array displays. The absence of any reference to discrete light emitting element type displays and in particular discrete LED arrays drives the conclusion

that the original intent of the cited references is limited to solely monolithic and integrated circuit display devices.

In contrast, Visioneered's application uniquely identifies the specific demands of electronic billboard display applications for discrete LED display optical compensation, algorithms, and optical, mechanical, electrical design and construction methods to compensate for light output changes due to intrinsic variation of LED components and change of luminance output due to aging, humidity, temperature, ambient light, usage or failure. While the general concept of optical feedback from a light source to modulate the light source output is known in the art, the mechanisms necessary to adapt the concept to the wide array of existing display technology types is unique to each type.

On this basis, it is my opinion that Visioneered's application provides enhancement and unique invention over the prior art.

By: Stewart Hough

Stewart Hough

State of California

County of Madera

Subscribed and sworn to (or affirmed) before me on this 8th day of September 2006. By Diana J. Tucker, Notary Public or proved to me on the basis of satisfactory evidence to be the person(~~s~~) who appeared to me.

Diana J. Tucker

Notary Signature

DIANA J. TUCKER
Commission # 1530066
Notary Public - California
Madera County
My Comm. Expires Nov 26, 2008

**STEWART HOUGH**
12920 Road 37
Madera, CA 93638
TEL: 559-645-1034
FAX: 559-645-1035
Mobile: 559-871-5685
Home: 559-645-5236
Email: Business - shough36@comcast.net
Home – slndchough@sti.net

## *Experience Summary*

Development and commercialization of emerging technologies in electronics, electronic displays, solid-state lighting and power conversion:

- 15 yr. Engineering and Engineering Management,
- 13 yr. Business Development, Intellectual property (IP), Executive Management and Market Management in start-up and large corporate environments in the U.S., Europe and Asia.

## *Career Experience*

- **Advanced Technology Applications, Madera, CA** **9/91- Present**
  President, owner: Design and consulting to display, lighting and technology industries – emerging technologies, OLED, LCD, EL, MEMS LED, lighting technology commercialization, IP consulting, development and management, competitive analysis, marketing and business strategies. Consulting, design and licensing infra-red touch systems and flat panel displays.

- **Cambridge Display Technology, Cambridge, UK** **11/00 – 10/03**
  Vice President, Business Development: Start-up company developing OLED technology. Managed strategic business development for technology licensing, IP, joint technology, venture and market development in North America, Europe and Asia for electronic displays, lighting, photovoltaics and organic electronics. Global corporate communications management, company spokesman.

- **Candescent Technologies, Inc., San Jose, CA** **5/97 – 10/00**
  Marketing Manager: Start-up company developing FED electronic display technology. Developed technology roadmaps for electronic display markets and display products for new technology in global OEM markets. Business development, competitive IP review and development, company spokesman, strategic partner negotiations, technology evaluation, OEM and channel customer development, PR management.

- **Fujitsu Microelectronics, Inc., San Jose, CA** **9/95 – 5/97**
  Plasma Display Business Manager, Western Hemisphere: Japanese electronics company developing plasma display technology. Management of profit and loss, market, product and technical development responsibilities. Market penetration through strategic business alliances. Launched new plasma products for HDTV and large screen display markets.

- **Advanced Tactical Avionics and Controls, Madera, CA** **8/90-9/91**
  Vice President, Engineering: Start-up company design, IP generation, and development of infra-red touch systems and displays for custom and OEM markets.

- **Pentastar Electronics, Hunstville, AL** **9/89 - 8/90**
  Senior Engineer: design engineering, technical marketing for commercial and military display products. Bid and proposal, systems, electrical and mechanical design.

- **AMP, Inc., Round Rock, TX** **1/81 - 4/89**
  Advanced Development and Engineering Manager: Design and development of touchscreens and LCD and EL display products - technical, product and market management. Managed 15 engineering personnel for $8 million business division.

- **RCA, Inc., Solid State Division, Lancaster, PA** **5/78 - 11/81**
  Associate Engineer: CCD closed circuit camera product design and development.

### *Professional Accomplishments*

Patent #4,684,801 - Signal Preconditioning for Touch Entry Device

Patent #4,818,859 - Low Profile IR Touch System Design

Additional Inventions - Integrated display, touch system and optical filter, Enhanced resolution technique for IR touch systems, Merged sensor technique using pressure verification, Improved noise and fault-tolerance techniques for IR touch systems, AC-LED drive methods

Corporate Executive/Advisor –

V.P. Business Development - Lynk Labs, Inc.,

Director of Engineering – Driven Technologies, Inc.

Conference speaker – numerous business, new technology and displays

Conference chair – SEMI, Intertech OLED

Course lecturer - plasma, FED and OLED technology, IP, business strategies

Board member - US Display Consortium, 2001 - 2003

Consultant – Fortune 100 and 500 companies

Published articles – numerous international marketing, business and technology publications

Patent analysis and consulting

### *Education*

1980 Millersville University, Lancaster, PA - B.S. Physics